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PATENT

Ramjet Engine Incorporating a Tubular Structure and a Missile Propelled by a Ramjet Engine of this Type

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FIELD OF THE INVENTION

The present invention concerns ramjet engines and missiles propelled by these ramjet engines.

BACKGROUND OF THE INVENTION

Ramjet engines designed for missile propulsion are already well known. These engines, manufactured using steel or an aluminum alloy, have a complex structure and are heavy and costly.

SUMMARY OF THE INVENTION

The purpose of the present invention is to reduce the weight and cost price of such ramjet engines and to simplify their structure, in particular by eliminating a large number of mechanical connections while still obtaining a high degree of rigidity.

To achieve these goals according to the invention, the ramjet engine, includes ~~incorporating~~ a combustion chamber ending in a gas-ejection nozzle, a cruising propulsion unit which feeds gaseous ~~liquid~~ fuel into the ~~said~~ combustion chamber, and at least one air duct which feeds air intended for combustion of the ~~said~~ fuel into the ~~said~~ combustion chamber, with the ramjet engine containing ~~is distinguished by the fact that it contains~~ a rigid tubular element whose interior volume is divided into two spaces by ~~means of~~ an intermediate transverse wall ~~, one~~. One of ~~which~~ the spaces houses the ~~said~~ cruising propulsion unit while the other space houses the ~~said~~ combustion chamber. Passages are ~~passages~~ cut into the ~~said~~ intermediate transverse wall to permit feeding of gaseous ~~liquid~~ fuel into the ~~said~~ combustion chamber, ~~;~~ and the ~~said~~ air duct is mounted on the ~~said~~ tubular element so as to feed combustion air through the tubular wall of the ~~said~~ tubular element.

It will be seen that an especially simple, inexpensive, and rigid ramjet-engine structure may thus be obtained.

The [Said] tubular element is advantageously made of a composite material formed from resistant fibers, for example, glass or carbon fibers, coated with a polymerizable synthetic resin, for example, epoxy, phenolic, PSP, or polyimide. Production of a tubular element of this kind entails the application of conventional techniques for the manufacture of volumes by filament winding on a mandrel using resistant fibers impregnated with a hardenable resin.

Thus, because of the use of such winding techniques for the production of a ramjet engine, not only is advantage gained from the use of composite filament-based materials providing outstanding mechanical properties for a density less than that of metals, but, in addition, the original design features of this invention may be embodied in a simpler, lighter, and less costly ramjet-engine architecture.

For example, as will be seen below, the filament-winding technique makes possible the incorporation of a large number of components, such as the nozzle, thermal protective linings, and intermediate wall, in a single operation, thereby simplifying ramjet-engine manufacture. Moreover, the use of a composite material for the production of the engine have been proposed which allows the simple implementation of the pyrotechnical process for cutting the apertures through which the air ducts open into the combustion chamber [, as described in Patent Application No. 88 07844, filed June 13, 1988 in the Applicant's name]. When,

according to conventional practice, the ramjet engine contains a consumable accelerator which, when installed in ~~said~~ the combustion chamber, is designed to impart initial propulsion to the missile, this process makes it possible to cut ~~said~~ the apertures only when the cruising propulsion unit is ignited, upon completion of the combustion of said accelerator. Thus, problems of a weakened structure inhering in the existence of ~~said~~ the apertures and aggravated by the high pressure generated by ~~said~~ the accelerator are eliminated.

Of course, the specifications of ~~said~~ the tubular element allow it to bear the operating stresses of the ramjet engine, in particular the combustion pressures of the engine and of the optional consumable accelerator, as well as the structural stresses (resistance, rigidity) linked to the missile. Furthermore, as is customary for conventional metal ramjet engines, a thermal protection lining is provided on the interior walls of ~~said~~ the tubular element, at least in the space corresponding to the combustion chamber.

It will be noted that, because of the present invention, the various elements, such as the intermediate transverse wall, the thermal protection lining, the nozzle, the optional consumable accelerator, and the cruising propulsion unit, may be joined to ~~said~~ the tubular element in various ways~~:~~. ~~(a) They~~ For example, the above-noted elements may be attached by bonding or mechanical attachment, or ~~they~~ may be molded within said tubular element~~;~~.

No ¶ Alternatively such elements

(b) They may be positioned on the winding mandrel of the said tubular elements and thus incorporated into the tubular element it during its the manufacture by filament winding;.

It is also possible for the elements to be built at

(c) They may be built in their intended locations and simultaneously within simultaneously with the tubular element, elements so as to form a monolithic assembly (this being is the case when the materials composing the various components are similar composite materials).

Additionally, in accordance with the present invention, the

(d) Said components may be grouped into two sub-assemblies so as to obtain:

No ¶ – a first, a "combustion-chamber" sub-assembly made up of the intermediate transverse wall, the thermal protection linings, and the ramjet engine nozzle;

- and second, a "cruising propulsion-unit" sub-assembly composed made up of components corresponding to the type of ramjet engine chosen.

of the above

These sub-assemblies are then inserted and attached on the inside of the tubular element, thereby thus ensuring the mechanical solidity of the assembly, with the. This last manufacturing technique method is being particularly recommended for the cruising propulsion unit, which is then incorporated into a sub-structure manufactured using filament winding.

The special nature of the "cruising propulsion-unit" sub-assembly design, which consists of a wound volume which is slid into and fastened to the interior of the tubular element, makes it possible to have a single main structure for several different

types of ramjet engines, including:

For example, one type of ramjet engine may be

- a simple ramjet engine in which said sub-assembly contains a semi-solid propellant block for cruising, which can in consequence be molded and bonded onto said tubular element;

and consequently,

However, it is also possible in accordance with the present invention to provide

- a gas-generating ramjet engine, termed "separate," in which said sub-assembly contains, in addition to the free semi-solid propellant block, an ignition system and sonic injectors;

generally

It is also possible to provide

- a liquid-fuel ramjet engine, in which said sub-assembly comprises a fuel tank, its fluid-driving generator, and its injection system.

including a

Thus, among the major special features of the present invention, which will be described more clearly below, may be mentioned:

The , in accordance with the present invention,

- Said intermediate transverse partition may be made directly unitary with said rigid tubular element.

unitarily or inversely by one of the two assemblies, for example, the "cruising propulsion unit" and the "combustion chamber".

- Inversely, said intermediate transverse partition may be made unitary with said rigid tubular element by means of one of the two sub-assemblies, i.e., the "cruising propulsion unit" and the "combustion chamber."

It is also possible for at least one of constituted in the

- Of the two sub-assemblies made up of said cruising propulsion unit and of said combustion chamber respectively, at least one may be manufactured inside of said tubular element.

to internally the

or as an alternative the

NOTE - As a variant, at least one of said assemblies may be manufactured as a module, installed, and attached within said tubular element.

In accordance with still further feature of the present invention
In yet another variant, said tubular element may be constructed around at least one of the two assemblies made up of said cruising propulsion unit and of said combustion chamber; and

No ¶ Said tubular element may for example, incorporate inserts for attachment of said air ducts;

The These inserts are advantageously provided intended to attach the ends of said air ducts to said tubular element in the area of the combustion chamber and may be made unitary with said intermediate transverse partition.

Additionally, the Said combustion chamber may in accordance with the present invention, incorporate a consumable accelerator; and the

No ¶ Said inserts, for attaching intended to attach the ends of said air ducts to said tubular element in the vicinity of said combustion chamber, may shaped so as to form cutting knives to cut the air-feed apertures in the walls of said tubular element at the appropriate moment.

BRIEF DESCRIPTION OF THE DRAWINGS

The attached drawings will promote understanding of the way in which the invention may be built. In these drawings, identical references designate similar components.
The above and other objects, features and advantages of the present invention will become more apparent from the following description when taken in connection with the accompanying drawings which show, for the purpose of illustration only, several embodiments in accordance with the present invention, and wherein:

Figure 1 is a partial longitudinal cross-section of a missile equipped with a ramjet engine conforming to the present invention;
Fig. 1 is a partial longitudinal cross-sectional view of a missile equipped with a ramjet engine constructed in accordance with the present invention,

Figure 2 is a longitudinal cross-section, on a larger scale, of the ramjet-engine example according to the invention, illustrated in Figure 1.
Fig. 2 is a longitudinal cross-sectional view on an enlarged scale, of the ramjet-engine of Fig. 1.

Fig. ~~Figure~~ 3 is a partial cross-sectional view ~~cross-section~~ of an ~~example of installation of the~~ air duct shipment in a ~~the~~ vicinity of the tubular element~~.~~;

Fig. ~~Figure~~ 4 is a cross-sectional view taken ~~cross-section~~ along line IV--IV of Figure 3~~.~~;

Figs. ~~Figures~~ 5 and 6 are cross-sectional views of ~~cross-sections illustrating~~ other embodiments of the ramjet engine according to the invention.

Figs. ~~Figures~~ 7 through 19 are diagrammatic illustrations of an example of a process for constructing ~~the procedure used to build~~ the ramjet engine shown in Figs. ~~Figures~~ 1 and 2~~.~~; and

Figs. ~~Figures~~ 20 to 32 are diagrammatic representations of an example of a process ~~procedure~~ for the construction of another ramjet engine in accordance with ~~conforming to~~ the present invention.

DETAILED DESCRIPTION

~~The~~ missile ~~(1,)~~ constructed in accordance with ~~conforming to~~ the invention ~~and shown in Figure 1,~~ includes ~~has~~ a body 2 rigidly extended ~~rigidly~~ toward a ~~the~~ rear by a ramjet engine 3 for providing a ~~which provides~~ propulsion for the ~~said~~ missile. The body 2 includes ~~contains~~ the usual devices and loads, which are not represented since they are not related to the invention.

Air ducts 4 are arranged on the circumference of the missile 1 and are attached to said ramjet engine. Each of these ducts incorporates, toward the front, an air intake 5 and, toward the rear, a bend 6 allowing its attachment to the exterior wall of said ramjet engine 3.

As will emerge clearly from the following description, the ramjet engine 3 according to the invention may be built according to a large number of variant embodiments, and may be constructed in several different ways. However, whatever the embodiment, the

Referring now to the drawings wherein like reference numerals are used throughout the various views to designate like parts and, more particularly, to Fig. 1, according to the figures, a

ramjet engine 3 comprises (see the enlarged Figure 2:

- a rigid tubular element 7 made by the filament-winding on a mandrel of resistant fibers coated with a hardenable resin;
- an intermediate transverse partition 8 separating the interior volume of said tubular element 7 into two spaces, 9 and 10 respectively, of which one, i.e. forward space 9, houses the cruising propulsion unit 11, while the other, i.e., rear space 10, is designed to house the combustion chamber of said ramjet engine 3;
- passages 12 cut in said transverse partition, in order to allow feeding of liquid fuel from the cruising propulsion 11 unit into the combustion chamber;
- a gas-ejection nozzle 13 fitted at the rear extremity of space 10 opposite to the transverse partition 8; and
- a thermal protection lining 14 covering at least the inner wall of space 10. Thus, the combustion chamber is formed from said nozzle 13 and said lining 14.

In the embodiment show in Figures 1 and 2, it has been assumed that a thermal protection lining 15 has also been formed on the surface of the transverse partition 8 facing the space 9 containing the cruising propulsion unit 11.

A consumable accelerator 16 may be installed on the inside of the combustion chamber 13, 14.

Furthermore, inserts 17 and 18 may be incorporated into the rigid tubular element 7 for the purpose of attaching the air ducts 4 onto the ramjet engine. The inserts 17 are fitted onto

the forward end of said tubular element 7 and make it possible to attach the intermediate (or forward) part of the air ducts 4 (see Fig Figure 1). On the other hand, inserts 18 are installed in the vicinity of the intermediate transverse partition 8, but just to the rear of it (i.e., facing the space 10 making up the combustion chamber) with the inserts 18 making; they make it possible to make the rear extremities of the air ducts 4 unitary with the side wall of the tubular element 7 after the bends 6 in the said ducts.

Figs Figures 3 and 4 illustrate, on an enlarged on a larger scale, the attachments of the rear extremities of the air ducts 4 to the inserts 18. In Figs 3 & 4 these figures, it has been assumed that each air duct 4 contains, within its bend 6, an obstacle 19 dividing the said air duct into two passages 4a and 4b, with each of which is designed emptying to empty, into the forward portion (just to the rear of the partition 8) of the combustion chamber 13, 14 through openings 20a and 20b, respectively.

The rear extremity of the air ducts 4 ends in a collar 21, which may be attached to the tubular element 7 using fastening means (only the axis of which 22 of which is shown for purposes of clarity) such as screws driven through the wall of said tubular element 7 and the said inserts 18.

Openings 20a and 20b may be drilled mechanically in the wall of the tubular element 7 prior to attachment of the air ducts 4 to the tubular element 7 this latter. These openings may preferably also be drilled in the said wall at the precise moment when the cruising propulsion unit 11 is ignited in a conventional manner., as is explained in the above-mentioned patent)

application. In this case, pyrotechnic cutting fuses 23 are installed on the inner circumference of passages 4a and 4b and against the wall of said tubular element 7. The inserts 18 provided for attachment of the air ducts 4 are, in this case, ring-shaped, the inner circumference of which 24 acts as a knife for the cutting of the wall of the tubular element 7 by the pyrotechnic fuses 23.

The missile 1 thus functions in the following manner:

Initially, since the ramjet engine 3 is not operational, the missile is propelled by the consumable accelerator 16 (composed, for example, of a solid-propellant load) housed within the combustion chamber 13, 14.

When the accelerator 16 is operating:,

No ¶ - the air ducts 4 are blocked by the wall of the tubular element 7 sealing the openings 20a, 20b at the intake of the
defined by the nozzle and the lining
combustion chamber 13, 14;

No ¶ - an A acceleration nozzle, smaller than the nozzles that 13) of the ramjet engine, is positioned at the outlet of the combustion chamber 13, 14. The This nozzle 25 may be composed of a simple tube formed in the accelerator block 16.

When the accelerator 16 ceases operation, the said acceleration nozzle 25 is ejected and the pyrotechnical fuses 23 are activated. The openings 20a and 20b are thus cut out, and air, flowing (arrow F) in the air ducts 4 through the openings 5, is drawn into the combustion chamber 13, 14, through the openings 20a and 20b created in this way.

Simultaneously, the cruising propulsion unit 11 is activated to ensure the continued propulsion of the missile 1, which has already been propelled by the consumable accelerator 16, until flight is completed.

The intermediate transverse partition 8 may be made either of metal, or, preferably, of a fiber-resin composite material, having the same nature as that used to make the element 7. In the event that the intermediate partition is metal, it may form a monobloc hood in combination with the inserts 18.

The partition may be:

No ¶ — inserted and bonded to the inside of the polymerized tubular element 7;

No ¶ — or inserted in the winding mandrel of ~~said~~ the element and incorporated into this latter during the winding of the composite material;. Additionally, the partition may be manufactured

No ¶ — ~~or manufactured~~ using resin-impregnated fabrics set between two parts of the mandrel and incorporated into the tubular element 7 when ~~this latter~~ the tubular element 7 is wound, the entire unit being polymerized together to form a monolithic structure;.

No ¶ — Additionally ~~finally~~, ~~it~~ the partition may make up the front extremity of a secondary structure containing all of the components of the integrated accelerator 16.

Similarly, the nozzle 13 of the ramjet engine 3 may be:

No ¶ — inserted and bonded to the interior of the polymerized element 7;

NOIP [- or placed in the winding mandrel of said element and incorporated into it when the composite material is wound(;).

The nozzle 13 may also be

NOIP [- or] formed directly on the mandrel, for example by winding a fringe of resin-impregnated(,) fireproof material of the type described in (for example, [as described in] French Patent [84 12782] 8,412,782 of August 14, 1982(), or by positioning of specifically-oriented fabrics, then incorporated into the element 7 when [this latter] the tubular element is wound, with the entire unit being polymerized together so as to form a monolithic structure(;).

It is also possible for the nozzle 13 to be

NOIP [- or finally, it may] made part of a secondary structure comprising all of the components of the integrated accelerator 16.

The protective lining 14 may be installed in three different ways[:], with the first being a conventional approach, which is achieved

NOIP [- conventionally,] by the protective liner molding on [the inside] an interior of the tubular element 7, after polymerization of [this latter;] the tubular element.

It is also possible for the protective lining 14 to be molded and

NOIP [- or, by molding it] around a mandrel, [polymerizing it], and then [winding] wound the tubular element 7 on the assembly thus polymerized formed. In this situation [case], and if the desired thermal protection is silicone-based, a bonding layer must be laid down on what will be the surface of the thermal protection on which the winding of the tubular element 7 will take place[;].

Additionally, the protective lining 14 may be installed , for example,

NOIP [- or] by placing a layer several millimeters thick ([e.g.] 4 to 12) of a fiber-resin material on the mandrel. The fibers may be made of silica or silicon carbide, and the resin must be compatible with that used in the tubular element 7.

This thermal protection may be installed by filament winding (incorporating the slightest possible angle to restrict ablation), by winding a fringe, or by encasing the mandrel in a three-dimensional fabric cover. The ramjet-engine nozzle 13 may also be formed simultaneously and using the same procedure.

The tubular element 7 is then wound on this thermal protection, and the unit thus formed is polymerized.

Finally, the thermal protection lining 14 may constitute part of a secondary structure comprising all of the elements of the integrated accelerator 16. It is then installed using one of the three methods previously described.

As was indicated above, the accelerator 16 is preferably of the solid-propellant type without added nozzle, consisting of a propellant block with a central channel 26 and a mouth 25 tube 26 at the rear (forming a nozzle) which is molded and bonded in the combustion chamber 10. The choice of this type of accelerator is made in the interest of extreme simplicity of design. However, in the event that the disadvantages linked to the presence of a nozzle (i.e., greater complexity and ejection threatening the carrier) are not considered to rule out its use, the accelerator 16 may be fitted with a nozzle, this nozzle latter (not shown) being incorporated into the tubular element 7, then ejected when the accelerator 16 has burned up, for example, by means of pyrotechnic cutting.

In the embodiment represented in Figs Figures 1 and 2, the cruising propellant unit 11 is assumed to comprise a semi-solid

propellant block 27 and an ignition system 28.

NUP In this case, the reduction gases burned in the chamber 9 of the ramjet engine are generated by the pyrolysis of the semi-solid propellant block 27 which has been molded and attached in ~~said~~ the chamber, and are injected into the combustion chamber 10 through the large passages 12 cut in the intermediate partition 8.

The block 27 may be installed in the chamber 9 in any appropriate manner. However, the block will preferably be molded and bonded onto a secondary structure 29 (for example, a structure constructed by filament winding), which is then slid into position and bonded inside the chamber 9 of the tubular element 7.

It will be noted that the secondary structure 29 contains no rear extremity (in order to allow molding of the block 27), and that its side wall does not have to be furnished in order to withstand the operating pressure of the propulsion unit 11. Indeed, corresponding stresses are borne by the side wall of the tubular element 7, against which said secondary structure rests for support. On the other hand, the forward end of the secondary structure 20 is furnished so as to withstand the operating pressure of the propulsion unit.

Fig ~~Figure~~ 5 illustrates an embodiment of the ramjet engine 3, in which the cruising propulsion unit 11 is of the solid propellant type with separate gas generator. In this case, a semi-solid propellant block (which may be doped with boron),

which generates the reducing gases serving as fuel for the ramjet engine, may be free. ~~In consequence~~ Consequently, it is simple to position it in the chamber 9. An ignition system 31 is provided, and the passages 12 cut in the partition 8 thus become sonic injectors 32. As before, a secondary structure 29 enclosing the block 30 may be provided.

In the embodiment shown in ~~Figure~~ Fig 6, the cruising propulsion unit 11 comprises a tank 33 of liquid fuel, a system 34 for the injection of the fuel into the ~~chamber~~ space 10, and a system 35 which drives the fuel from the tank 33 to the injection system 34. Here again, the propulsion unit 11 may be installed in different ways, in particular using the secondary structure 29.

It will be noted that the construction of the propulsion unit 11, of whatever type, as a plug-in cartridge 29 is worthy of consideration, since it allows a standard elementary structure (comprising the tubular element 7, the wall 8, the nozzle 13, and the accelerator 16) to be equipped with the propulsion unit best suited to requirements.

Using ~~Figures~~ Figs 7 through 19, an example of the ~~procedure~~ process for ~~the construction~~ Constructing of the ramjet engine 3 shown in ~~Figures~~ Figs 1 and 2 will be ~~illustrated~~ described below.

First, two cylindrical mandrels 40 and 41, having the same diameter, are readied; they may be made unitary coaxially, one mounted on the end of the other, because of a system of male 42 and female 43 plugs fitted respectively in the rear extremity 44 of the mandrel 41 and in the forward extremity 45 of the mandrel

40.

understood from the following description

As will be seen below, mandrels 40 and 41 correspond to chambers 10 and 9, respectively. Mandrel 40 has on its surface, in the vicinity of its forward extremity 45, indentations in which the inserts 18 (Figure 7) are fitted. Furthermore, ceramic sleeve tubes designed to form passages 12 are positioned on the male plugs 42 (Figure 8).

Next, layers 46 of fabric woven from resistant fibers impregnated with polymerizable resin are placed on the rear extremity 44 of mandrel 41; said sleeve tubes 12 protrude through these layers (Figure 9). In a symmetrical arrangement, layers 47 of fabric woven from resistant fibers impregnated with polymerizable resin are placed on the forward extremity 45 of mandrel 40, said layers 47 being pierced with holes 48 opposite the female plugs 43 (Figure 10).

The two mandrels 40 and 41 are joined together one mounted on the end of the other, in such a way that the layers 46 and 47 are pressed together between said rear and forward surfaces 44 and 45, respectively, so as to ultimately form the transverse partition 8. In this position, the portions of the sleeve tubes 12 protruding beyond the layers 46 pass through the holes 48 and are inserted into the female plugs 43 (Figure 11).

This assembly is placed on a bobbin winding machine, which creates on the joined mandrels 40 and 41 filament windings, for example windings alternately polar and circumferential. Thus, a composite wall 50, made up of several layers and designed to form

the tubular element 7, is obtained, in which metal inserts, such as, for example, the inserts 17 used to mount the air ducts 4, may be incorporated during winding (see Figure 12).

The entire structure thus obtained is polymerized, either in an oven or an autoclave, depending on the type of resin used.

The wound extremities 51 and 52 are cut at the two ends, and the winding mandrels 40 and 41' removed. The structure 7, 8, 9, 10, 12, 17, and 18, ~~represented~~ illustrated in Figure 13, is then obtained.

The nozzle 13 is then bonded to the rear of the chamber 10 of the structure (Figure 14), and the thermal protective surfaces 14 and 15 are molded within the structure (Figure 15). The acceleration propellant block 16 is molded in a similar manner (Figure 16).

Furthermore, as illustrated in Figure 17, a secondary composite structure 53, fitted with a polar seat 54 at its forward end 55, is wound on another mandrel 56. It may, for example, be made of a single winding layer having a slight angle of winding. This secondary structure 53 is then polymerized; then, once its rear extremity 57 is sectioned, it is unmolded so as to form the secondary structure 29 (Figure 18).

The semi-solid propellant block is molded inside of the secondary structure 29 (Figure 19); next, this secondary structure 29 is positioned and bonded in the chamber 9 of the structure shown in Figure 16, so as to form the ramjet engine 3 illustrated in Figures 1 and 2.

A variant embodiment of the ramjet engine in accordance with

the invention, containing a liquid fuel tank similar but not identical to the tank 33 shown in Figure 6, will now be described with reference to Figures 22 to 33.

A mandrel 60 equipped with a projecting shaft 61 is constructed for manufacture of the ramjet-engine fuel tank. This mandrel may be either a soluble mandrel or a cylindrical volume made of an very thin aluminum alloy; this latter volume, which forms a permanent, integral part of the finished tank, makes it possible to obtain a high degree of impermeability, in the event it is feared that the composite to be wound thereafter cannot perform this function (Figure 20).

The resistant structure 62 of the fuel tank is constructed by means of filament winding of resistant fibers impregnated with the same resin as that to be used to construct the tubular element 7 (Figure 21).

Two additional pieces of the mandrel 63 and 64 are mounted on the shaft 61 at either end of the tank 62 wound in this manner (not yet polymerized); a main structure 65 (analogous to structure 50 in Figure 12) is constructed by filament winding on the large mandrel 60, 63, 64 thus obtained (Figure 23). All metal inserts (such as 17) required for mounting various assemblies (air intakes, control surfaces, etc.) are added during this winding procedure.

The assembly made up of the main structure 65 and the fuel tank 62 is polymerized.

Following the sectioning of the ends created by the winding

of the main structure 65, the two additional mandrel pieces 63 and 64 are unmolded. The assembly 7, 17, 62 illustrated in Fig Figure 24, is then obtained.

In addition, a mandrel 66 which is either soluble or dismountable using keys is made in the exact shape of the ramjet-engine combustion chamber yet to be built. The combustion chamber will be built on this mandrel, and will contain, in addition, the integrated accelerator. Shafts 67, which will give material existence to the apertures required for the insertion of the injectors, are positioned in the forward end of the mandrel.

A hood made of silica fibers, impregnated with resin, and in which openings 69 have been cut corresponding to the air intakes 20a, 20 b, is positioned on the front portion of the mandrel 66. Next, a cover 70 designed to form the intermediate partition 8 is placed over the hood. This cover 70 contains openings 71 matching the air intakes 20a, 20b (Fig Figure 26), and the cover 72 it may either be made of metal or molded by compression of a a high-performance resin loaded with suitably-placed carbon fibers. Various parts, such as those required for mounting the injectors and the ignition device (not shown), are inserted.

Silica fibers impregnated with resin are wound on the remaining cylindrical part of the mandrel 66, so as to form a lining 72 (Fig Figure 27). Thus, thermal protection 14 is provided by the hood 68 and the lining 72.

Disks 73 made of polymerized thermal protective material are placed in the air-intake openings (Fig Figure 27).

A thin wrapping 74, covering all of these components, is created by low-angle filament winding of carbon fibers. The purpose of this wrapping is to join all of the components forming a module 75 designed to be inserted in the combustion chamber (Figure 28).

The assembly described above is polymerized; next, once the rear extremity of the wound wrapping is cut away, the mandrel is dissolved or taken apart and withdrawn from the module 75 of the combustion chamber thus formed (Figure 29).

An acceleration propellant block 26 is then molded in the module 75 of the combustion chamber (Figure 30), after which the cover 70 is fitted with an injection system 76 (Figure 31).

The module 75, thus equipped with the integrated accelerator 16 and the injection system (76), is slid into the structure shown in Figure 24. Care is taken to position the air-intake apertures correctly. The assembly is then cemented (Figure 32).

The cruising propulsion unit 11 is then completed through the forward opening 62a cut by the shaft 61 in the tank 62 (Figure 33).